The Evaluation of the Effectiveness of Water Absorbent Polymers in Reducing the Irrigation Needs of Potted Plants

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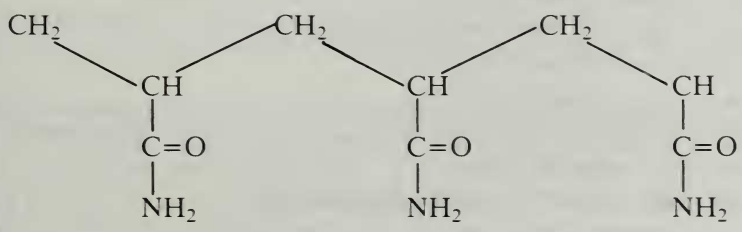
Abstract

The available-water-enhancing effects of the water-absorbent polymers, Agrosoke, Soiltex G1 and Terra-Sorb, on a typical local sandy-clay topsoil were evaluated, using *Mussaenda* Dona Luz, *Tecomaria capensis*, and *Hibiscus rosa-chinensis* as indicator plants. Results did not indicate significant beneficial effects at the three rates of polymers used. Instead, the practicability of using sludge to augment the water-holding capacity of the topsoil was validated.

Introduction

Synthetic polymeric soil conditioners are increasingly being used as modifiers of physical soil attributes such as water-holding capacity and permeability, with promising results (Azzam, 1985; Callebaut et al, 1979: De Boodt., 1979 and Gunn, 1984). Many of the synthetic soil conditioners are polyacrylamide-based, having the following basic structure.



An interesting property of these polymeric soil conditioners is their ability to hold many times their own weight in plant available water (Flannery & Busscher, 1982; Gehring & Lewis III, 1980 and Hamilton & Lowe, 1982). Moreover, rehydration of spent conditioners is possible after the available water is depleted by plant uptake and evaporation. Consequently, they have been used in potting media, especially those of open and sandy nature, to enhance their water-holding capacity thereby reducing the watering frequency (Flannery & Busscher, 1982 and Gehring & Lewis III, 1980).

In the Republic of Singapore, watering is a horticultural operation which is not yet fully mechanized. In some cases, watering of potted plants in the nurseries is accomplished by manual labour. Therefore, if plant growth media could be physically altered by polymeric additives to hold more water, labour expended on watering and water itself, a scarce resource, can be saved.

Materials And Methods

The effects of three polyacrylamide-based polymeric conditioners viz: Agrosoke (Chemical Discoveries (UK) Limited), Soiltex G1 (Interlates Limited, UK) and Terra-Sorb (Industrial Services International, Inc.), on the water-holding capacities of a local topsoil (a sandy clay loam of composition 53% sand, 24% silt and 23% clay; pH 5.5) were investigated.

The indicator plants selected were *Mussaenda* Dona Luz, *Tecomaria capensis* and *Hibiscus rosa-sinensis,* all known to be susceptible to water stress. Uniform plants, especially in terms of leaf coverage, of the above species were chosen and inplanted into a standard amount of topsoil alone, topsoil with treated and pulverized sludge in the ratio 3:1 v/v (standard departmental mix for planting holes), topsoil with 3 rates of each conditioner (Table 1) or a synthetic topsoil of formulation 1/3 Rengam subsoil: 1/3 treated and pulverized sludge: 1/3 granite dust (v/v/v; pH 6.2) (Teoh & Chua, 1975; Wells, 1977). Clay pots of dimensions 23 cm (top internal diameter) × 16 cm (height) × 18 cm (bottom internal diameter) were used and each was packed with 4.5 kg of substrate. The treatments are summarized in Table 1.

Table 1

Summary of treatments

Treatment	Specification
A	Control: topsoil without additive
B	Topsoil: Agrosoke (2000:1/w/w)
C	Topsoil: Agrosoke (1000:1 w/w) (Recommended rate)
D	Topsoil: Agrosoke (1000:2 w/w)
E	Topsoil: Soiltex G 1 (2000:1 w/w)
F	Topsoil: Soiltex G 1 (1000:1 w/w) (Recommended rate)
G	Topsoil: Soiltex G 1 (1000:2 w/w)
H	Topsoil: Treated sludge (3:1 v/v)
I	1/3 Rengam subsoil: 1/3 Treated sludge: 1/3 granite dust (v/v/v; synthetic topsoil)
J	Topsoil: Terra-sorb (2000:1 w/w)
K	Topsoil: Terra-sorb (1000:1 w/w) (Recommended rate)
L	Topsoil: Terra-sorb (1000:2 w/w)

The conditioners were mixed with the topsoil in the deactivated state and later activated by repeated flooding after the plants were established in the mixes.

All treatments and control were replicated 6 times for each plant species used, giving a total of 72 pots per plant species. After implantation, plants were arranged in randomized complete blocks and allowed to establish for a week under a shed of transparent polythene cover. This provided shelter from the rain while leaving ample room for air circulation and heat transmission.

To initiate the trial, pots were soaked thoroughly and allowed to drain for half an hour to achieve field capacity. Immediately, a 10 g sample of substrate was collected from a depth of 8 cm from each pot for the determination of moisture content at field capacity by drying to constant weight at 105°C. For the first 4 days, sampling was done twice daily, once at 10 a.m. and the other at 4 p.m. Thereafter, sampling was carried out once daily in the afternoon for moisture determination until the permanent wilting point was reached. The number of days taken to reach the permanent wilting point was recorded (DTW). The difference between the moisture content at field capacity and that at the permanent wilting point yielded the index for plant-available water.

Results And Discussions

Results on total water contents, available water contents and days-to-wilting (DTW) are presented in Tables 2, 3, 4 and 5. Data were analysed with the Duncan Multiple Range Test for significance.

Data in Table 2 indicated that the departmental planting mix comprising 3 volumes of topsoil to 1 volume of treated sludge was significantly superior to all other treatments in terms of total water-holding capacity. Total water-holding capacity was similar with or without adding polymers to topsoil (cf. Control (A) and treatments with conditioners in Table 2). Increasing the rate of conditioner in certain cases did not result in a higher total water-holding capacity (cf. Treatments (B) and (C), and Treatments (E), (F) and (G) in Table 2). It appeared that the three rates of conditioners applied did not augment significantly the water-holding capacity of the topsoil, a sandy clay loam. Also, according to Flannery & Buscher (1982), the full capacity of polymeric soil conditioners could only be effected after long periods of saturation.

In the case with *Tecomaria capensis* as the indicator plant (Table 3), DTW was not affected by treatments. The available water contents did not relate to the rates of the soil conditioners added. In fact, the highest rate of soiltex Gl appeared to be the poorest in maintaining available water for the trial plant. In terms of available water, Treatments H (the departmental planting mix) and A (Control) yielded results better than Treatment G but comparable to those of other treatments.

In the case with *Hisbiscus rosa-sinensis* (Table 4), no significant treatment-difference on available water was detected. However, the effect of Treatment H on DTW was significantly better than a majority of other treatments. DTW was similar in the absence (A, control) and presence (Treatments B, C, D, E, F, G, J, K and L, Table 4) of polymers in the topsoil.

Table 2

Effects of various treatments on the total water-holding capacities

Treatment	A	B	C	D	E	F	G	H	I	J	K	L
Total water (%)	21.58 bg	22.55 be	21.04 cdefg	22.07 bf	24.33 b	23.19 bd	18.73 cg	27.19 a	18.55 cg	18.26 c	19.04 cfg	20.03 cefg

Treatments A-L have reference in Table 1.
Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P<0.01$.

Table 3

Effects of various treatments on the number of days taken to reach the permanent wilting point (DTW) of *Tecomaria capensis* and the available water contents

Treatment	A	B	C	D	E	F	G	H	I	J	K	L
DTW	16.0a	14.7a	14.5a	15.0a	15.5a	16.0a	16.0a	16.8a	13.8a	14.0a	12.5a	15.8a
Available water (%)	18.4 ad	20.4 a	16.3 bcd	16.0 bd	18.9 ad	20.3 ac	12.0 b	16.9 ad	18.0 ad	16.2 bd	16.7 ad	19.1 ad

Treatments A-L have reference in Table 1.
Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P<0.01$.
DTW = Days to Wilting.

Table 4

Effects of various treatments on the number of days taken to reach the permanent wilting point (DTW) of *Hibiscus rosa-sinensis* and the available water contents

Treatment	A	B	C	D	E	F	G	H	I	J	K	L
DTW	10.0 abc	9.7 abc	10.7 abc	11.5 cd	10.2 abc	10.8 cd	14.2 bd	15.5 d	9.0 abc	7.50 ac	9.7 abc	8.0 ac
Available water (%)	18.2 a	17.1 a	18.3 a	20.2 a	19.9 a	19.3 a	21.0 a	22.4 a	14.9 a	16.5 a	17.5 a	16.3 a

Treatments A-L have reference in Table 1.
Values in each row if not followed by the same letter are significantly different as judged by the DMR testt at $P<0.01$.
DTW = Days to Wilting.

Table 5

Effects of various treatments on the number of days taken to reach the permanent wilting point (DTW) of *Mussaenda* Dona Luz and the available water contents

Treatment	A	B	C	D	E	F	G	H	I	J	K	L
DTW	5.7a	5.8a	5.5a	5.5a	5.8a	5.2a	5.0a	5.5a	4.3a	5.0a	5.3a	5.3a
Available water (%)	15.9 a	17.6 a	15.5 a	15.5 ac	20.1 a	17.1 a	10.3 bc	16.3 a	16.7 a	14.9 ac	16.7 a	18.1 a

Treatments A-L have reference in Table 1.
Values in each row if not followed by the same letter are significantly different as judged by the DMR test at $P<0.01$.
DTW = Days to Wilting.

Mussaenda Dona Luz appeared to be the most susceptible to water stress among the three indicator plants selected. It reacted to water stress by shedding its leaves. The first sign of leaf drop was therefore construed to be the permanent wilting point. Results obtained with this trial plant showed no significant treatment effect on DTW (Table 5) and only marginal effects on available water. As with *Tecomaria capensis*, there was no significant correspondence between the rate of conditioner applied and the water-holding capacity. Treatments H and A were significantly different from Treatment G but similar to all other treatments in terms of available water.

Conclusion

The present trial did not show any significant enhancing effect of polymers on the water-holding capacity of a typical topsoil. Control A, irrespective of the indicator plant used, showed similar effects in total water-holding capacity, available water and DTW to those of treatments with conditioners. Our results indicated that the standard planting mix of the Parks and Recreation Department compared more than favourably to topsoil treated with various rates of the polymeric soil conditioners, in the three attributes measured.

However, our results do not rule out the possible usefulness of these polymers in sand or more sandy soils, for which such products are more intended for, and in

planting where a larger volume of substrate is involved. In fact, Gehring & Lewis III (1980) have found significant relationships between the wilting time and the container size used in their study of a polymeric soil conditioner.

References

Azzam, R.A.I. (1985). Tailoring polymeric gels for soil reclamation and hydroponics. Commun. In *Soil Sci. Plant Anal.*, 16, 1123-1128.

Callebaut, F., Gabriels, D. & M. De Boodt (1979). The effect of polymer structure on soil physico-chemical properties and soil water evaporation. *Journal of Chemical Technology & Biotechnology*, 29, 723-729.

De Boodt, M. (1979). Soil conditioning for better soil management. *Outlook on Agriculture*, 10, 63-70.

Flannery, R.L. & W.J. Busscher (1982). Use of a synthetic polymer in potting soils to improve water-holding capacity. Commun. *In Soil Sci. & Plant Anal.* 13, 103-111.

Gehring, J.M. & A.J. Lewis III (1980). Effect of hydrogel on wilting and moisture stress of bedding plants. *J. Amer. Soc. Hort. Sci.* 105, 511-513.

Gunn, S. (1984). Like a sponge. *GC & HTJ*, August 10, 19, 21 & 24.

Hamilton, J.L. & R.H. Lowe (1982). Use of a water-absorbent polymer in tobacco seedling production and transplanting. *Tobacco Science,* XXXVI, 17-20.

Page, E.R. (1982). Soil conditioners. *Scientific Horticulture*, 33, 1-13.

Teoh, T.S. & S.E. Chua (1975). The performance of several ornamental shrubs in different potting mixtures of subsoil, sludge and granite dust. *Singapore J. Pri. Ind.*, 3, 21-34.

Wells, N. (1977). The role of soils in the utilization of sludge in Singapore. *N.Z. Soil Bureau Scientific Report 30.* Department of Scientific & Industrial Research, New Zealand.